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STUDY OF THE ELONGATION OF HORNS

OF THE VENUS CRESCENT IN JUNE 1964

by

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(F R A N C E)

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ABSTRACT

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The photometry of the aureole prolonging the horns of Venus at in-
ferior conjunction indicates that the atmosphere above the cloud layer re-
mains charged of particles of approximately 1.5 μ in diameter, whose num-
ber decreases by a factor of 2 approximately every 2.8 km and whose dif-
fusion coefficient is 3.10^{-8} stilb/phot per centimeter cube contrary to
the Sun at the level of the cloud layer. *Authors*

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On 19 and 20 June 1964, the planet Venus passed in inferior conjunc-
tion at 2^{0} from the Sun; the phase angle V attaining $177^{0}.6$ and the fili-
form crescent showing the elongated horns under the form of an almost com-
plete luminous circle. Between 6 June (V = 151^{0}) and 4 June (V = 150^{0})
the authors obtained 29 series of negatives to the direct focus of the 60 cm
refractor of Pic du Midi, during twenty different days.

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* Étude de l'allongement des cornes du croissant de Vénus en juin 1964.

The circular sunshade 80 cm in diameter, borne by a mat of 13 m fixed to the rim of the cupola, cast a shadow on the objective in order to suppress the reflection and the diffusion of the solar light by the surfaces of lens in the same way as the very brilliant background that it produces.

After the exposures, the objective was covered by a very small diaphragm (approximately 2 cm) and by a thin plate of absorbant glass (transmission near 0.01) pointing at the Sun. Negatives of the center of the solar disk were taken with durations of increasing exposures bordering those necessary for the obtaining of negatives of Venus. These additional images allow a direct comparison between the light intensity of Venus and the illuminance E_0 given by the Sun.

PHOTOMETRY OF NEGATIVES --- Let $\varkappa = 0^\circ$, the azimuth of the radius of the planetary disk directed in opposition to the Sun, $\varkappa = +90^\circ$ corresponds to the Northern horn and $\varkappa = -90^\circ$ to the Southern horn.

The negatives have been measured radially by microdensimeters every 5° and at the same time the calibration marks and the negatives of the solar surface. The intensity of the aureole is given for a small arc $\Delta\alpha$ subtended by one degree around the azimuth α ; it corresponds to the equivalent width of the photometric profile and is related to the intensity for an area of $(1")^2$ at the center of the solar disk. In dividing the disk surface and after correction of darkening at the rim is made, the ratio of the aureole intensity under $\Delta\varkappa = 1^\circ$ to the illuminance E_0 given by the Sun at the distance from the Earth, is obtained.

The measurements under $\alpha = 90$, 80, 60 and 45° (average values for

the Northern and Southern horns) are plotted in Figure 1 as functions of phase angle V; the values of $\bar{\Phi}$ are plotted in ordinates on the right hand scale.

OPTICAL TRAJECTORY IN THE UPPER ATMOSPHERE --- Let us divide the atmosphere of Venus above the upper level of the visible cloud layer taken as the origin of altitudes $z = 0$ km in concentric layers of altitude z increasing (real altitude $z = 0$ is poorly defined if the clouds are cumulus-shaped). The aureole stems from the diffusion by residual particles in suspension in these higher regions of the atmosphere. Each layer includes $N(z)$ diffused particles by unit volume; their diffusion coefficient, assumed independent of the altitude, is $R(V)$. Each layer contributes to the aureole shine proportionally to a trajectory $T(V, \alpha, z)$ that we have calculated numerically as a function of z for different values of α and of V. Thus, each layer gives the diffused light

$$\Phi(V, \alpha, z) = R(V)\,N(z)\,T(V, \alpha, z).$$
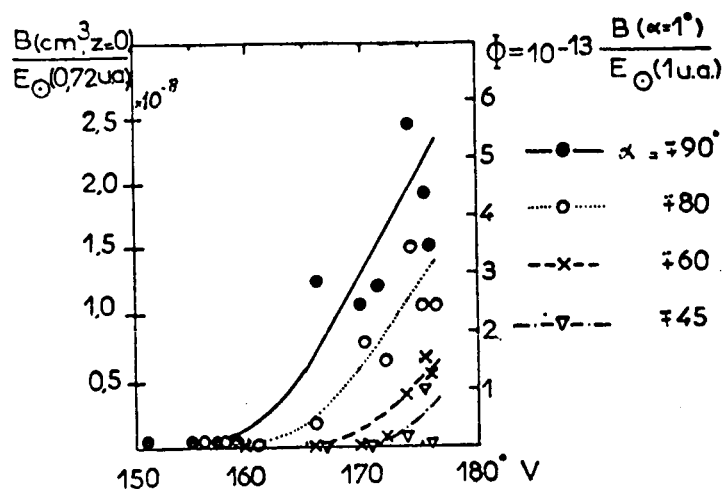

Figure 1

While neglecting the proper absorption and the multiple diffusion, the
total intensity of the aureole under the azimuth α is equal to

$$\Phi(V, \alpha) = R(V) \int_{z_0}^{z} N(z)\, T(V, \alpha, z)\, dz \qquad (1)$$

with

$$z_0 = r\left[1 - \cos\left(\frac{\pi - V}{2} \cos \alpha\right) \right] \qquad \text{(r being the radius of Venus)}$$

DIFFUSION INDICATRIX AND DIAMETER OF PARTICLES --- The trajectory to the
exact horns of the corona for $\alpha = +90°$ and $-90°$, is expressed by $T = 2\sqrt{2rz}$
and subsists independently from the phase angle V. The curve, drawn in a
solid line thus reproduces (Figure 1) the diffusion indicatrix R(V), of
particles in suspension in the upper atmosphere of Venus, above the cloud
level. The latter diffuse the light with a strong concentration contrary
to the direction of the source and the diffusion is already almost 0 at
$20°$ from this direction.

For the opaque dust particles, the diffraction formula $S = 1{,}22\, \lambda/2a$
gives a diameter of 2 a near 2 μ. For transparent spheres of index
near 1 the formulae of Mie, computed by Van de Hulst, give 2 a near 1.5 μ .

VERTICAL DISTRIBUTION OF PARTICLES --- According to Figure 1, the inten-
sities observed respectively for $\alpha = 80$, 60 and $45°$ become progressively
weaker; they correspond to trajectories in the atmosphere of Venus above
increasing altitude z_0 and characterize in a certain measure the verti-
cal distribution of diffused dust particles.

In Figure 2, we have plotted the observed values as functions of
1 — cos α , for the two phase angles V = $170°$ and V = $175°$ (dashed curves).
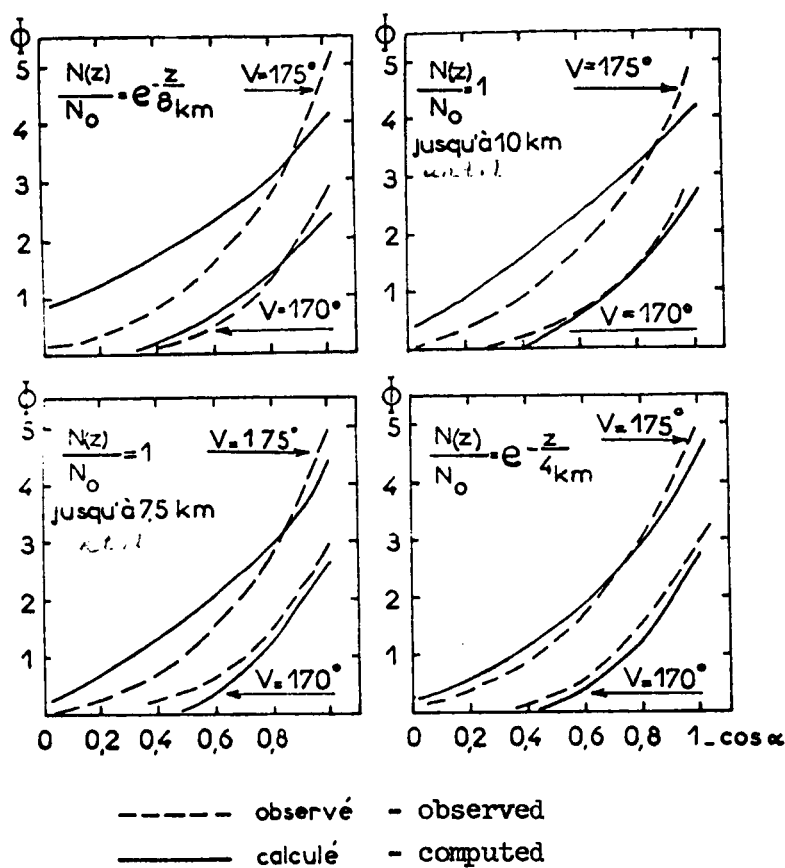These curves have been compared with those computed beginning with

Figure 2

equation (1) for four hypotheses on the vertical distribution N(z) of
particles:

   a. The number of particles decreases proportionally to the
      atmospheric pressure:

$$N(z) = N_0\, e^{-\frac{mz}{KT}} = N_0\, e^{-\frac{z}{8km}}$$

   b. The number is constant to the altitude 10 km and subsequently
      is zero.

   c. The number is constant to the altitude of 7.5 km and subse-
      quently zero.

d. The number decreases twice faster than the atmospheric pressure:

$$N(z) = N_0 e^{-2\frac{mg}{kT}z} = N_0 e^{-\frac{z}{1.4km}}.$$

The best agreement is obtained in the last case (Figure 2). Thus, the particles rarefy continually but rapidly above the cloud layer $z = 0$ by approximately a factor of 2 for every 2.8 km.

These particles can form either a regular mist, or scattered veils whose average density complies with the preceding decrease.

DIFFUSION COEFFICIENT PER CENTIMETER CUBE OF PARTICLES --- While assuming the preceding vertical distribution, equation (1) is written for the points of the crescent as follows:

$$\Phi(V) = B(V) \int_0^\infty N_0 e^{-2\frac{mg}{kT}z} \cdot \sqrt{9.7z} \, dz.$$

The numerical calculation of the integral gives $2.10^{20}.N_0 cm^3$.

If d and d' are the distances from the Earth and Venus to the Sun, the aureole intensity, referred to the illuminance received from the Sun by Venus, is equal to $\Phi(V)(d/d')^2$; its relative brilliance will be $\Phi(V)(d/d')^2[1/(d-d')^2]$ that is $\Phi(V) \times 8.8 . 10^{21} cm^{-2}$.

The diffused brilliance by particles in 1 cm^3 at $z = 0$ km per unit of illuminance will be $\Phi(V) 8.8 . 10^{21}/2 . 10^{20}$ that is $4.4 . 10^1 \Phi(V)$ stilb/phot.

The values are plotted in Figure 1, in the left hand ordinate scale for the distance Sun - Venus from 0.72 a. u. Extrapolated for $V = 180°$, the diffusion coefficient for 1 cm^3 at $z = 0$ will be 3.10^{-8} stilb/phot (1 cm^3 of pure air in normal conditions diffuses to 90° from the source $0.55.10^{-8}$ stilb/phot).

Thus the particles remain very scarce.

The variable irregularities of the brightness of the horns, the luminous nodosities of the aureole and the measurement dispersion indicate that the abundance of particles can vary from one region to another and in time, by more than a factor of five.

*** THE   END ***

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